**Embedded Processors**

**AMBA Bus**

Dalia Iurascu  
Alejandro Vázquez Bofill

Lund University

---

**What is an Embedded Processor?**

"Embedded" into a device, it delivers **real-time** behavior in power sensitive applications.

Architecture as: Motorola 68000 (68K), Intel x86, AMD 29000(29K), Intel i960.

---

**Contents**

- Embedded Processors
  - Overview
  - Design features
  - AMBA Bus System
    - Why AMBA
    - AMBA AHB, APB Structure
    - AMBA Test Interface
  - Conclusions
  - References

---

**Shipment of Embedded Processors**

*Figure 1: Marketing projections*

J. Hennessy, "The Future of Systems Research"
Usage

- Consumer electronics
- Communication
- Automotive

Lorem, more of these, though they cost a lot less each.

Where are the embedded devices?

Why is this important?

- Give products programmability and flexibility
- Eliminate components
- Potential for future product upgrades (embedded software update)

Characteristics

- Application Specific Processors
- Static Structure
- Non-homogeneous
**Number of embedded processor cores**

![Comparison FPGA & Non-FPGA Designs]

**Good Embedded Processors**

- Performance
  - Latency
  - Bandwidth (throughput)
- Cost
  - Area
  - Complexity

**μP/μC/DSP**

- μC
  - single chip
  - memory, I/O ports
  - CISC processors
- μP
  - CPU
  - memory, I/O ports to be connected externally
  - RISC
- DSP
  - specialized microprocessor
  - designed for digital signal processing
  - real time
DSP-advantages

- Versatility
  - Reprogrammed for other applications

- Repeatability
  - Easily duplicated

- Simplicity

---

Nios II Embedded Processor

- Most used processor in the FPGA industry
- Five-Stage pipelined general-purpose RISC microprocessor
- Supports both 32-bit and 16-bit architectural variants
- Both utilize a 16-bit instruction format to reduce code footprint and instruction memory bandwidth

---

Nios II

- Configurable

- Easily combined with user logic and programmed into a PLD

- Advanced features, such as custom instructions

- Simultaneous multi-master Avalon bus

- Powerful processing solution

---

ARM-ISA

- Load-Store RISC Architecture

- 32 bit Architecture

- All instructions are predicated

- 16 Registers
  - R0-R14-general purpose register
  - R15-program counter

- 32 bit instructions
ARM Embedded Processors

- Architectural simplicity
- Small implementations
- Very low power consumption

Cortex M3

- High performance 32-bit CPU
- Develop high performance low-cost platforms
- RISC processor core
- Low latency 3-stage pipeline
- Optimal blend of 16/32-bit instructions

AMBA-ARM designed

- Advanced Microcontroller Bus Architecture
- On-Chip communication standard
- Signal protocol-connect multiple blocks in SOC
- High-performance bus standard
- High speed cache interfaces

- AMBA
  - AHB(Advanced High Performance)
  - ASB(Advanced System Bus)
  - APB(Advanced Peripheral Bus)

Why AMBA?

- Design for low power consumption
- Partitioning high and low-bandwidth devices
- Low costs
- Test access
  - Integrate optional on-chip test access methodology
  - Reuses the basic bus infrastructure
- Support of multiple development platforms
- Easier to port real time kernel software
ARM AMBA Bus

- Microprocessor
- On-chip RAM
- Off-chip RAM
- DMA Bus Master
- UART
- Timer
- APB
- Keypad
- PIO

Fig. 1. Typical AMBA-based Microcontroller

Dalia Iurascu, Alejandro Vazquez Bofill

AMBA Bus (cont.)

- High speed bus (ASB or AHB) for CPU
- Fast memory and DMA
- Bus for peripherals (APB)
  - Connected via a bridge to the high-speed bus

Dalia Iurascu, Alejandro Vazquez Bofill

AHB/APB

- **AHB**
  - High performance
  - Pipelined operation
  - Burst transfer
  - Multiple Bus Masters
  - Split transactions
  - Bus width: 8, 16, 32, 64, 128 bits

- **APB**
  - Low power
  - Latched address and control
  - Simple Interface
  - Suitable for many peripherals

Dalia Iurascu, Alejandro Vazquez Bofill

ASB

- High performance
- Pipelined operations
- Multiple bus masters
- Burst transfers
- Bus width: 8, 16, 32 bits

Dalia Iurascu, Alejandro Vazquez Bofill

Dalia Iurascu, Alejandro Vazquez Bofill
AMBA AHB Structure

- Initiate request to arbiter

Decoder
- Decode the address of each transfer
- Select the signals from the slave

Master:
- Initiate read and write operations
- Provide address and control information
- Only one bus master use actively the bus at one time

Slave:
- Respond to a read/write operation

Arbiter
- Ensures that only one bus master has access to the bus
- Each bus master can request the bus, the arbiter decides which has the highest priority and issues a grant signal accordingly

AMBA AHB Structure (cont.)

Decoder
- Decode the address of each transfer
- Select the signals from the slave

Master:
- Initiate read and write operations
- Provide address and control information
- Only one bus master use actively the bus at one time

Slave:
- Respond to a read/write operation

AMBA AHB Architecture
APB Components

AHB to APB Bridge

- Latching of all address, data and control signals
- Drive data for a write transfer
- Drive data for a read transfer

APB Components (cont.)

APB Slaves

- Un-Pipelined
- Zero power interface
- Write data valid for the whole access

ARM7 Processor

Figure 5. PID7T, the AMBA-based development card for the ARM7 processor family.

AMBA Test Interface

- Provides access to inputs/outputs of peripheral that are not directly connected to the bus

Dalia Iurascu, Alejandro Vazquez Bofill
Convert the external test vector into internal bus transfer.

**Inputs for Test Interface**

- **TCLK**
  - Test clock input signal
  - Must not glitch

- **TREQA**
  - Test bus request A
  - Request entry into the test mode

**Inputs (cont.)**

- **TREQB**
  - Test bus request B
  - Type of test vector in the following cycle

- **TACK**
  - Gives external indication that test bus has been granted

- **TBUS-bidirectional**
  - Apply address, control write vectors

**Conclusions**

- **Embedded processors**
  - Widely used and sold
  - Customized for a specific application
  - Typically have fewer resources compared with General purpose processors
Conclusions-AMBA

AMBA Bus

- Bus-excellent communication medium to connect several devices
- Shared communication-bottleneck in the system
- Technology independent
- Ensures that highly reusable peripheral can be migrated across a diverse range of IC processes

References


Thank you

Questions?